Evidence for ‘Magnetic Rotation’: Lifetimes of States in the M1–bands of ^{198,199}Pb

R.M.Clark[1], *S.J.Asztalos*[1], *G.Baldsiefen*[2], *J.A.Becker*[3], *L.Bernstein*[3], *M.A.Deleplanque*[1], *R.M.Diamond*[1], *P.Fallon*[1], *I.M.Hibbert*[4], *H.Hübel*[2], *R.Krücken*[1], *I.Y.Lee*[1], *A.O.Macchiavelli*[1], *R.W.MacLeod*[1], *G.Schmid*[1], *F.S.Stephens*[1], *R.Wadsworth*[4]

[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley CA 94720, U.S.A.*

[2] *Institut für Strahlen– und Kernphysik, Universität Bonn, D–53115 Bonn, Germany*

[3] *Lawrence Livermore National Laboratory, Livermore, California 94550*

[4] *Department of Physics, University of York, Heslington, York, YO1 5DD, UK*

The observation of long cascades of magnetic dipole transitions in the neutron deficient Pb nuclei has posed a serious challenge to conventional collective models. They are thought to be based on high–K proton configurations coupled to neutron configurations involving low–K $i_{13/2}$ holes. The properties of the bands are extremely unusual: 1) the structures follow the rotational I(I+1) rule over many states despite very low deformations; 2) the levels show no signature splitting; 3) the levels are linked by strong M1 transitions with a typical B(M1) of the order of several Weisskopf units; 4) the B(M1)/B(E2) ratios are very large (typically $\geq$20-40 μ_N^2/e^2b^2); 5) the ratio $\Im^{(2)}$/B(E2) is roughly ten times larger than that for well deformed nuclei. It has been suggested that the bands represent a novel mode of nuclear excitation, namely ‘magnetic rotation’ which arises as a consequence of breaking the intrinsic rotational symmetry by a large magnetic dipole (as opposed to the more familiar ‘electric rotation’ which arises when an electric quadrupole (deformation) breaks the symmetry).

An intuitively appealing description of the behaviour of the M1–bands naturally arises from the Tilted Axis Cranking (TAC) model [1]. Close to the band–head the proton and neutron angular momentum vectors are coupled almost perpendicular to each other. The total angular momentum vector, $\underline{J}$, then lies along a tilted axis (see Fig. 1). Angular momentum is generated as the proton and neutron angular momentum vectors slowly tilt towards $\underline{J}$. This has been called the ‘shears mechanism’. Since the magnetic transition probability is determined by the components of the magnetic moments perpendicular to $\underline{J}$, the B(M1) should drop with increasing spin. This is a crucially important prediction, since the B(M1)’s are a sensitive probe of the underlying mechanism. Previous attempts to deduce B(M1)’s through lifetime measurements have proven inconclusive. A new high–precision measurement of lifetimes of states in the M1–bands of ^{198,199}Pb has been performed using Gammasphere [2]. The deduced B(M1) values show a remarkable agreement with the TAC predictions (see Fig. 2). The results represent the first convincing proof of the phenomenon of nuclear ‘magnetic rotation’.

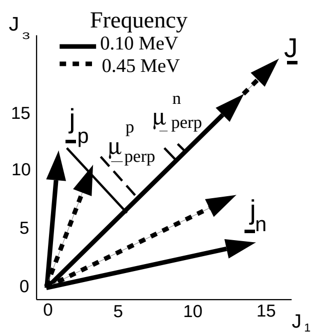

Fig1: The TAC Mechanism

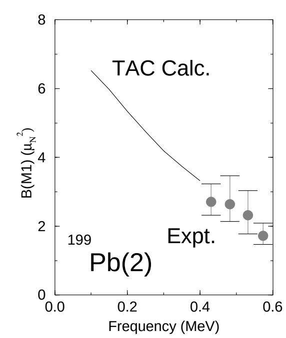

Fig2: B(M1)’s: TAC vs. Expt

References

[1] S. Frauendorf, Nucl. Phys. A 557 (1993) 259c

[2] R. M. Clark et al., accepted, Phys. Rev. Lett.